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Impact of Pesticide Exposure on Germination of Selected Legume and Cereal Crops Grown in Northeastern Nigeria.

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***Abstract*— *The increasing adoption of chemical pesticides in sub-Saharan Africa has raised concerns among farmers about potential phytotoxic effects on staple crops. This study evaluated the impact of four commonly used products; Butaforce (butachlor), Glyweli (glyphosate), Kombat (lambda-cyhalothrin) and Weed Crusher (paraquat) on seed germination and early seedling growth (plumule and radicle) of cowpea (Phaseolus vulgaris), maize (Zea mays), pearl millet (Pennisetum glaucum), rice (Oryza sativa) and sorghum (Sorghum bicolor). Seeds were exposed to three concentrations (1.25, 2.5 and 5.0 ml L^{-1}) of each pesticide, with water-treated seeds serving as control. Data were subjected to one-way ANOVA at 5% significance level. Results showed that Kombat caused no significant reduction in germination or seedling growth; at 2.5 ml L^{-1} it even enhanced plumule and radicle elongation in cowpea, and at 5.0 ml L^{-1} further stimulated radicle growth relative to control. In contrast, Weed Crusher exerted the strongest inhibitory effect on both germination percentage and plumule/radicle development across all species. Butaforce and Glyweli also suppressed germination at higher concentrations, though to a lesser extent than Weed Crusher. These findings demonstrate that pesticide effects are both compound-specific and dose-dependent. Farmers are advised to integrate pesticide application within an integrated pest management framework to optimize crop productivity and environmental sustainability. Farmers can also integrate biocontrol agents into their crop protection strategies to reduce reliance on synthetic pesticides and mitigate phytotoxic risks.*

***Keywords*— Pesticide, Cereal, Legume, Germination**

I. INTRODUCTION

Food grains, often referred to as staple crops, play a pivotal role in global diets, serving as primary sources of carbohydrates, proteins, and other essential nutrients. According to the Food and Agriculture Organization (FAO), grains contribute more than 50% of the world's caloric intake (1). Common examples include rice, wheat, maize, barley, and oats, each offering distinct nutritional benefits; rice as a key energy source and wheat providing significant protein content. Sorghum and millet are high energy food sources and legumes like cowpea and Bambara groundnut are essential protein sources (2) Beyond their nutritional value, grains are integral to global food security due to their storability, enabling sustained food supplies during periods of scarcity (1). Additionally, cultivating diverse grain species supports sustainable agricultural systems by enhancing soil health, reducing erosion, and minimizing dependence on chemical fertilizers (3).

Crop production faces significant threats from a variety of biotic stressors, including insect pests, pathogenic fungi, viruses, and weeds. To mitigate these threats, both organic and synthetic pesticides are commonly applied in agricultural systems. These chemical agents, comprising fungicides, herbicides, nematicides, molluscicides, germicides, and antimicrobial compounds are widely used to safeguard crops (4). The global intensification of agricultural practices, particularly in developing countries, has led to a marked increase in pesticide usage. Over the past decade, pesticide usage has risen by an estimated

153% increase in low-income countries (5). While many developed nations have banned the use of certain toxic and environmentally persistent pesticides, such substances remain in circulation in countries like Nigeria, where regulatory enforcement is less stringent (6). In Northern Nigeria, the influx of newly introduced pesticides, often lacking clear labeling and chemical composition disclosure especially concerning heavy metal content raises substantial concerns (7). Investigations have revealed that many pesticides in the region, although not officially banned by Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC), contain hazardous elements such as Zn, Cd, Pb, Cu, and Cr (8, 9).

Synthetic pesticides are now deeply embedded in modern agricultural systems, particularly for the protection of vegetables and other high-value crops. While effective against pests and diseases, their widespread application has raised significant environmental and health concerns. These chemicals are associated with the development of pest resistance, biodiversity loss, pollution, and potential harm to human and animal health (10). Importantly, their toxic effects are not limited to target organisms. Emerging evidence suggests that synthetic pesticides can adversely affect non-target species, including crops, by disrupting growth, reproduction, and physiological functions (11). Studies have reported that pesticide exposure can impair pollen viability (12), interfere with plant reproductive processes (13), hinder plant growth and yield (14), reduce germination rates (15) and alter morphological and physiological traits (15, 16, 17). In particular, excessive use of fungicides has been linked to physiological disorders in plants (16), underscoring the potential for pesticides to negatively influence early plant development stages, such as germination.

The accumulation of pesticide residues and heavy metals in agricultural ecosystems presents a growing threat to food safety and environmental health. These contaminants are known to persist in food products and can enter the food chain through biomagnification, posing risks to both consumers and farmers (17). Heavy metals, in particular, are recognized as potent abiotic stressors, toxic to plants, animals, and humans alike (18, 19). Alarmingly, it is estimated that only about 1% of applied pesticides reach their intended targets, with the remaining 99% dispersing into the environment, contributing to environmental degradation (20). This inefficiency results in widespread contamination of soil and water resources, disruption of beneficial soil microbiota, and long-term ecological consequences (21, 22).

In light of these challenges, there is a pressing need to evaluate the unintended effects of commonly used pesticides on key agricultural crops, particularly during early developmental stages such as germination. This study investigates the effects of selected pesticides on the germination of cowpea and cereals widely cultivated in Northeastern Nigeria, with the aim of informing safer and more sustainable pest management practices.

II. MATERIALS AND METHODS

Study Area

This study was conducted at Abubakar Tafawa Balewa University, Bauchi, Nigeria (Latitude: 10.2791° N, Longitude: 9.7939° E). The university is located within the Bauchi metropolis, which serves as the administrative capital of Bauchi State in northeastern Nigeria. Bauchi lies on the northern edge of the Jos Plateau at an elevation of approximately 616 meters above sea level. The city covers an area of 3,687 km² and had a population of 493,810 according to the 2006 census.

Sample Collection

Five crop species; *Phaseolus vulgaris* (black-eyed cowpea), *Pennisetum glaucum* (pearl millet), *Oryza sativa* (Faro 44 rice), *Zea mays* (maize), and *Sorghum bicolor* (red sorghum) were procured from Muda Lawal Market in Bauchi metropolis. Samples were randomly collected from various vendors to ensure representativeness. The seeds were sorted by species, stored in polythene bags, and transported to the Ecology Laboratory at Abubakar Tafawa Balewa University for subsequent preparation and treatment.

Pesticide Treatments

Four commonly used pesticides were selected for the experiment; one insecticide (Kombat, containing Lambda-cyhalothrin) and three herbicides (Butaforce [Butachlor], Glyweli [Glyphosate], and Weed Crusher [Paraquat]). Each pesticide was prepared in three different concentrations: one at the manufacturer's recommended dose (medium concentration), one below, and one above the recommended dose.

The concentrations were prepared as follows:

- Butaforce (Butachlor)
  - Low: 4.69 mL/L (4.7×10^{-3} mL/mL)
  - Medium: 9.38 mL/L (9.4×10^{-3} mL/mL)
  - High: 18.75 mL/L (18.8×10^{-3} mL/mL)
- Glyweli (Glyphosate)
  - Low: 9.38 mL/L (9.4×10^{-3} mL/mL)
  - Medium: 18.75 mL/L (18.8×10^{-3} mL/mL)
  - High: 25.00 mL/L (25.0×10^{-3} mL/mL)

- Kombat (Lambda-cyhalothrin)
  - Low: 1.25 mL/L (1.3×10^{-3} mL/mL)
  - Medium: 2.50 mL/L (2.5×10^{-3} mL/mL)
  - High: 5.00 mL/L (5.0×10^{-3} mL/mL)
- Weed Crusher (Paraquat)
  - Low: 4.69 mL/L (4.7×10^{-3} mL/mL)
  - Medium: 9.38 mL/L (9.4×10^{-3} mL/mL)
  - High: 18.75 mL/L (18.8×10^{-3} mL/mL)

Each of the five crop species was treated with all three concentrations of the four pesticides in a completely randomized block design (RCBD). Treatments were replicated five times (pentaplicates), with each replicate consisting of five seeds, resulting in a total of 600 Petri dishes and 3,000 seeds.

Germination Assay

Seeds were surface-sterilized in 5% sodium hypochlorite (NaOCl) for 10 minutes and subsequently rinsed five times with sterile distilled water. Five uniform seeds were placed in each 110 × 20 mm Petri dish lined with Whatman No. 3 filter paper. For treatment dishes, 10 mL of the prepared pesticide solution was added, while control dishes received 10 mL of distilled water. All Petri dishes were sealed with parafilm to prevent moisture loss and incubated in the dark at room temperature for five days.

Data Collection and Analysis

At the end of the incubation period, germination percentage, mean germination time (MGT), mean germination rate (MGR), plumule length, and radicle length were measured. One-way Analysis of Variance (ANOVA) was conducted using Minitab software to assess the statistical significance of differences between treatment groups and controls for each measured parameter.

III. RESULTS

The effect of four different pesticides treatments on germination and seedling growth of *Zea mays, Phaseolus vulgaris, Pennisetum glaucum, Oryza Sativa* and *Sorghum bicolor* were evaluated.

The germination rate of *Zea mays* exhibited a general decline with increasing concentrations of the tested agro-pesticides (TABLE 1). Treatments with Butaforce (butachlor), Glyweli (glyphosate), and Weed Crusher (paraquat) resulted in a concentration-dependent reduction in germination percentage, plumule, and radicle lengths. Conversely, seeds treated with Kombat (lambda-cyhalothrin) showed an increase in plumule length with rising concentrations. The control group recorded the highest germination percentage and the longest plumule and radicle lengths across all treatments. At the lowest concentration of Butaforce (4.69 mL/L), *Z. mays* achieved 20% germination with a plumule length of 5.70 cm and a radicle length of 9.20 cm. At the intermediate concentration (9.38 mL/L), germination increased to 76%, but both plumule and radicle lengths decreased to 3.40 cm and 2.56 cm, respectively. No germination was observed at the highest concentration (18.75 mL/L). Glyweli-treated seeds showed 58% germination at 9.38 mL/L with 0.82 cm plumule and 0.46 cm radicle. Increasing the concentration to 18.75 mL/L and 25.00 mL/L reduced germination to 56% and 44%, respectively, with further reductions in plumule and radicle lengths. For Kombat treatments, the lowest concentration (1.25 mL/L) resulted in 60% germination, with plumule and radicle lengths of 4.22 cm and 7.62 cm, respectively. Germination increased to 72% at both 2.50 mL/L and 5.00 mL/L, with corresponding plumule lengths of 4.74 cm and 5.06 cm and radicle lengths of 5.54 cm and 5.80 cm. In Weed Crusher treatments, 4.69 mL/L yielded 24% germination, with 0.62 cm plumule and 0.82 cm radicle. At 9.38 mL/L, germination dropped to 20%, with further stunting of growth (0.36 cm plumule and 0.24 cm radicle). Complete inhibition of growth was observed at 18.75 mL/L.

Similarly, *Phaseolus vulgaris* demonstrated declining germination rates and stunted plumule and radicle growth with increasing concentrations of Butaforce, Glyweli, and Weed Crusher (TABLE 2). The control group consistently exhibited the highest values across all parameters, except in the Kombat treatment seeds. When treated with 4.69 mL/L of Butaforce, *P. vulgaris* showed a germination rate of 20%, no plumule development, and a radicle length of 1.82 cm. No germination occurred at higher concentrations (9.38 and 18.75 mL/L). In Glyweli treatments, the lowest concentration (9.38 mL/L) resulted in 40% germination with no plumule growth and 1.66 cm radicle. The higher concentrations yielded no plumule growth, with radicle lengths of 1.70 cm (18.75 mL/L) and 1.26 cm (25.00 mL/L). Kombat treatment had a contrasting trend. The highest concentration (5.00 mL/L) recorded the highest germination rate (40%), along with 2.04 cm plumule and 3.76 cm radicle lengths. The lower concentrations (1.25 and 2.50 mL/L) yielded lower germination but showed varying plumule and radicle lengths. Notably, the middle concentration (2.50 mL/L) produced the longest plumule (2.50 cm) but had the lowest germination rate among the Kombat-treated groups. Treatments with Weed Crusher completely inhibited germination in *P. vulgaris*, with no observable plumule or radicle development. Overall,

pesticide exposure led to significant inhibition of germination and early seedling growth in both *Zea mays* and *Phaseolus vulgaris,* with the exception of Kombat, which had comparatively less phytotoxic effects, particularly on *P. vulgaris.*

A general trend of decreasing germination was observed with increasing pesticide concentration in *Pennisetum glaucum* (TABLE 3). Treatments with Butaforce, Glyweli, and Weed Crusher showed a steady reduction in germination percentage, plumule, and radicle lengths. Conversely, Kombat treated seeds exhibited an increase in growth metrics with rising concentrations. The control group displayed 100% germination and the greatest plumule and radicle development. At 4.69 mL/L of Butaforce, 92% germination was recorded, accompanied by 0.40 cm plumule and radicle lengths. This dropped to 22% germination at 9.38 mL/L, with both plumule and radicle reduced to 0.10 cm. Complete inhibition of germination was observed at 18.75 mL/L.

Glyweli treatments showed a gradual decline: at 9.38 mL/L, germination was 40%, with 0.32 cm plumule and 0.24 cm radicle. At 18.75 mL/L, germination fell to 36% (0.24 cm plumule, 0.20 cm radicle), and further declined to 32% at 25.00 mL/L with reduced growth (0.12 cm plumule, 0.14 cm radicle). In contrast, Kombat-treated seeds showed relatively improved responses. At 1.25 mL/L, germination was 68%, with 0.66 cm plumule and 3.20 cm radicle. This increased to 80% at 2.50 mL/L, with 0.92 cm plumule and 5.00 cm radicle. Although germination dropped to 52% at 5.00 mL/L, plumule length reached 1.18 cm, while radicle measured 2.92 cm. Notably, 2.50 mL/L produced the highest germination and longest radicle growth. Weed Crusher completely inhibited germination at all tested concentrations. Overall, both plumule and radicle development were significantly stunted across treatments, except for radicles treated with Kombat.

For *Oryza sativa* (TABLE 4), germination rates declined with increasing concentrations of all pesticides tested. The highest values across all growth parameters were recorded in the control group. Exposure to 4.69 mL/L of Butaforce resulted in 20% germination, with 0.10 cm plumule and radicle lengths. No germination occurred at higher concentrations (9.38 and 18.75 mL/L). Glyweli treatments yielded 48% germination at 9.38 mL/L (0.18 cm for both plumule and radicle), decreasing to 36% at 18.75 mL/L (0.10 cm plumule and radicle) and 24% at 25.00 mL/L with no further reduction in growth. Kombat exposure showed a positive trend: both 1.25 mL/L and 2.50 mL/L resulted in 76% germination, with plumule and radicle lengths of 0.62 cm/1.90 cm and 0.60 cm/1.50 cm, respectively. At the highest concentration (5.00 mL/L), germination peaked at 84%, with a plumule length of 10.68 cm, although radicle length declined to 0.76 cm. All concentrations of Weed Crusher completely inhibited seed germination. Overall, plumule and radicle development in *O. sativa* were markedly reduced across most treatments, with partial exception for radicles in the lower concentrations of Kombat.

In *Sorghum bicolor* (TABLE 5), the effects of pesticide concentration on germination and seedling growth are detailed in TABLE 5. A concentration-dependent decrease in germination was evident across all treatments except Kombat. The control consistently exhibited the highest values for all parameters. At 4.69 mL/L of Butaforce, S. *bicolor* achieved 72% germination with 0.62 cm plumule and 0.52 cm radicle lengths. These values declined to 48% (0.48 cm plumule, 0.30 cm radicle) at 9.38 mL/L and further to 20% at 18.75 mL/L, with only 0.04 cm growth in both parameters. In Glyweli treatments, a germination rate of 92% was observed at 9.38 mL/L with 0.20 cm plumule and radicle, dropping to 76% at 18.75 mL/L and 64% at 25.00 mL/L, both with constant growth values of 0.20 cm. Interestingly, the 25.00 mL/L treatment recorded higher germination than 18.75 mL/L. Kombat-treated seeds consistently maintained high germination rates: 92% at both 1.25 and 5.00 mL/L and 88% at 2.50 mL/L. Plumule and radicle lengths were 3.46 cm and 6.24 cm (1.25 mL/L), 2.98 cm and 5.36 cm (2.50 mL/L), and 2.72 cm and 4.82 cm (5.00 mL/L), respectively.

Weed Crusher treatments significantly suppressed growth. At 4.69 mL/L, germination was 60% with 0.22 cm plumule and 0.16 cm radicle. Germination declined sharply to 20% at 9.38 mL/L (0.08 cm plumule and radicle), with no growth observed at 18.75 mL/L. Overall, plumule and radicle growth were markedly reduced in all treatments, except for the radicles of S. bicolor exposed to Kombat, which retained considerable growth across concentrations.

IV. DISCUSSION

Pesticides, including herbicides, insecticides, and fungicides, are extensively utilized in agricultural systems to manage pests and enhance crop productivity. However, improper application or excessive concentrations can adversely affect seed germination and early seedling development. Several studies have demonstrated that certain pesticides disrupt enzymatic activity, alter hormonal signaling, and negatively impact soil microbial communities, collectively impairing germination and seedling vigor.

The findings of this study indicate that pesticide exposure significantly influences the germination and early growth of Zea mays, with the extent of phytotoxicity varying by pesticide type and concentration. Among the tested agrochemicals, Butaforce (butachlor) and Weed Crusher (paraquat) exhibited the highest toxicity, completely inhibiting germination at their maximum concentrations. In contrast, Kombat (lambda-cyhalothrin) had comparatively milder effects, resulting in only moderate reductions in germination and seedling growth. Notably, reductions in both plumule and radicle length across treatments underscore the detrimental effects of pesticide stress on seedling vigor, with radicle inhibition particularly severe in treatments with Glyweli (glyphosate) and Weed Crusher. These results are consistent with previous findings where pesticides such as chlorantraniliprole significantly reduced coleoptile and radicle length in maize seedlings in Turkey (23). Similarly, fungicide exposure has been associated with impaired germination and biomass accumulation in Cicer arietinum and *Zea mays* in India (24).

In Phaseolus vulgaris, herbicidal stress led to pronounced inhibition of both germination and seedling growth, especially under exposure to Butaforce and Weed Crusher. Complete inhibition at higher concentrations suggests interference with critical physiological processes such as enzymatic activity and hormonal regulation during germination. This inhibition of germination observed in this study aligns with reports of oxidative stress and reduced chlorophyll content in *P. vulgaris* following herbicide application (25). Interestingly, selective inhibition of plumule elongation, even when radicle growth persisted (as observed with low concentrations of Butaforce and Glyweli), indicates differential tissue sensitivity to chemical stressors. Kombat treatments resulted in minimal adverse effects, with some concentrations even promoting radicle elongation compared to the control. This aligns with earlier studies indicating stimulatory effects of lambda-cyhalothrin on plant growth, including enhanced root development in rice (26) and cowpea (27). Contrastingly, other studies in Pakistan have shown that lambda-cyhalothrin can affect seed germination and seedling growth in tomato plants, especially at higher concentrations (28). Another study conducted in Nigeria have also shown that at low concentrations, cypermethrin can stimulate radicle growth in cowpea (29).

Butaforce and Weed Crusher caused the most pronounced reductions in germination and seedling growth, particularly at higher concentrations. Butaforce completely inhibited seedling growth at its highest tested level, likely due to interference with cell division and elongation processes. This is consistent with previous studies in *Triticum aestivum,* where butachlor exposure resulted in chromosomal aberrations and a reduced mitotic index (30). While Glyweli exhibited moderate toxicity, Kombat treatment led to better germination and growth performance, even at elevated concentrations, suggesting that lambda- cyhalothrin may be less phytotoxic to *P. glaucum.* Weed Crusher, however, demonstrated complete inhibition of seedling development.

Oryza sativa showed substantial susceptibility to Butaforce and Weed Crusher, with both herbicides markedly suppressing germination at all concentrations. Butaforce completely inhibited germination at higher concentrations, indicative of disruption to key cellular mechanisms such as mitosis and elongation. Glyweli exerted less severe effects, with partial reductions in germination and growth, while Kombat exhibited minimal phytotoxicity. Notably, the highest Kombat concentration was associated with the greatest germination rate and plumule length, further supporting potential growth-promoting effects of lambda-cyhalothrin at sublethal doses. In contrast, Weed Crusher caused complete inhibition at all tested concentrations. Paraquat is known to induce reductions in chlorophyll content and early seedling mortality in rice according to a research conducted in Mississippi (31).

Pennisetum glaucum responded variably to pesticide exposure, with Butaforce and Weed Crusher causing the most significant suppression of germination and growth. Butaforce exhibited concentration dependent toxicity, markedly reducing both plumule and radicle elongation. This result aligns with previous reports linking herbicidal phytotoxicity to the disruption of metabolic pathways essential for seedling development (30). Although Glyweli had less pronounced effects on germination, it inhibited growth of plumule and radicle particularly at higher concentrations. Kombat (lambda-cyhalothrin) had little toxicity even at higher concentrations. While specific studies on lambda-cyhalothrin's phytotoxicity on *Pennisetum glaucum* are limited, its comparatively lower impact suggests its possibility to be less toxic to plants or more suited to the crop's physiology. Weed Crusher (paraquat) exhibited complete inhibition of seedling development, indicating strong phytotoxic effects. According to a study in Algeria, paraquat is known to induce oxidative stress in plants, leading to diminished chlorophyll content and reduced shoot and root biomass, as observed in fenugreek seedlings (32).

Growth of Sorghum bicolor was significantly stunted in across all pesticide treaments except for the radicle growth

in plants treated with kombat (lambda-cyhalothrin). Similar inhibitory effects were observed in other studies where glyphosate and paraquat treatments resulted in significantly reduced growth of *Sorghum bicolor* (17). A study conducted in Ghana reported that high concentrations DDT and lambda-cyhalothrin significantly reduced seed germination rate and seedling vigor in vegetables (33).

Overall, the results of this study demonstrate that pesticide induced phytotoxicity is both species and compound-specific, with herbicides generally exerting more detrimental effects than insecticides. While some agrochemicals such as lambda-cyhalothrin may exhibit growth-promoting effects at low concentrations, others such as paraquat and butachlor are consistently associated with severe inhibition of early plant development. These findings underscore the importance of carefully selecting and managing pesticide application to minimize ecological harm and ensure optimal crop establishment.

Table 1. Seed germination and mean plumule and radicle growth of Zea mays exposed to pesticides after 5 days.

Concentration (ml/L)	Germination (%)	MGT (days)	MGR	Mean ± SD (cm) Plumule	Radicle
Control	88	2.14	0.47	5.70 ± 1.56^{a}	9.20 ± 2.62^{a}
4.69 Butaforce	76	2.84	0.35	3.40 ± 1.74^{ab}	2.56 ± 0.66^{cd}
9.38 Butaforce	36	2	0.5	2.92 ± 2.12^{bc}	2.04 ± 1.26^{d}
18.75 Butaforce	0	0	0	0.00 ± 0.00^{d}	0.00 ± 0.00^{d}
9.38 Glyweli	44	2.36	0.42	0.82 ± 0.19^{cd}	0.46 ± 0.21^{d}
18.75 Glyweli	56	2.14	0.47	0.76 ± 0.37^{cd}	0.40 ± 0.10^{d}
25 Glyweli	56	2.64	0.38	0.66 ± 0.15^{cd}	0.38 ± 0.08^{d}
1.25 Kombat	60	2.44	0.41	4.22 ± 1.02^{ab}	7.62 ± 1.15^{ab}
2.5 Kombat	72	2.11	0.47	4.74 ± 0.96^{ab}	5.54 ± 1.36^{bc}
5 Kombat	72	2.33	0.43	5.06 ± 0.56^{ab}	5.80 ± 1.02^{bc}
4.69 Weed Crusher	24	2.17	0.46	0.62 ± 0.44^{cd}	0.82 ± 0.59^{d}
9.38 Weed Crusher	20	3.4	0.29	0.36 ± 0.21^{d}	0.24 ± 0.22^{d}
18.75WeedCrusher	0	0	0	0.00 ± 0.00^{d}	0.00 ± 0.00^{d}

Means in the same column that do not share a letter are significantly different at P≤0.05

Table 2. Seed germination and mean plumule and radicle growth of Phaseolus vulgaris exposed to pesticides after 5 days.

Concentration (ml/L)	Germination (%)	MGT (days)	MGR	Mean ± SD (cm) Plumule	Radicle
Control	65	3.69	0.27	2.20 ± 0.93^{a}	3.32 ± 1.06^{ab}
4.69 Butaforce	20	2	0.5	0.00 ± 0.00^{b}	1.82 ± 1.09^{bcd}
9.38 Butaforce	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
18.75 Butaforce	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
9.38 Glyweli	40	2	0.5	0.00 ± 0.00^{b}	1.66 ± 0.40^{bcd}
18.75 Glyweli	36	2	0.5	0.00 ± 0.00^{b}	1.70 ± 0.48^{bcd}
25 Glyweli	26	2	0.5	0.00 ± 0.00^{b}	1.26 ± 0.46^{cd}
1.25 Kombat	36	2.33	0.43	1.72 ± 0.98^{a}	2.50 ± 0.59^{abc}
2.5 Kombat	32	2	0.5	2.50 ± 1.57^{a}	3.36 ± 0.62^{ab}
5 Kombat	40	2	0.5	2.04 ± 1.16^{a}	3.76 ± 1.88^{a}
4.69 Weed Crusher	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
9.38 Weed Crusher	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
18.75 Weed Crusher	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}

Means in the same column that do not share a letter are significantly different at P≤0.05

Table 3. Seed germination and mean plumule and radicle growth of Pennisetum glaucum exposed to pesticides after 5 days.

Concentration (ml/L)	Germination (%)	MGT (days)	MGR	Mean ± SD (cm)	
				Plumule	Radicle
Control	96	2.21	0.45	3.36 ± 0.80^{a}	5.10 ± 1.47^{a}
4.69 Butaforce	88	4.41	0.23	0.26 ± 0.09^{bc}	0.26 ± 0.09^{bc}
9.38 Butaforce	20	5	0.2	0.10 ± 0.00^{bc}	0.10 ± 0.00^{c}
18.75 Butaforce	0	0	0	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}
9.38 Glyweli	64	2.38	0.42	0.30 ± 0.10^{bc}	0.36 ± 0.05^{bc}
18.75 Glyweli	56	2.29	0.44	0.26 ± 0.05^{bc}	0.26 ± 0.05^{bc}
25 Glyweli	52	2.54	0.39	0.26 ± 0.09^{bc}	0.26 ± 0.05^{bc}
1.25 Kombat	76	2.32	0.43	1.00 ± 0.26^{b}	4.60 ± 1.19^{a}
2.5 Kombat	64	2.38	0.42	0.74 ± 0.27^{bc}	5.20 ± 0.86^{a}
5 Kombat	68	3	0.33	0.76bc $\pm 0.27^{bc}$	2.24 ± 1.55^{b}
4.69 Weed Crusher	0	0	0	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}
9.38 Weed Crusher	0	0	0	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}
18.75 Weed Crusher	0	0	0	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}

Means in the same column that do not share a letter are significantly different at P≤0.05

Table 4. Seed germination and mean plumule and radicle growth of Oryza sativa exposed to pesticides after 5 days.

Concentration (ml/L)	Germination (%)	MGT (days)	MGR	Mean ± SD (cm)	
				Plumule	Radicle
Control	96	3.17	0.32	1.58 ± 0.67^{a}	2.44 ± 1.09^{a}
4.69 Butaforce	20	5	0.2	0.10 ± 0.00^{b}	0.10 ± 0.00^{d}
9.38 Butaforce	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
18.75 Butaforce	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
9.38 Glyweli	48	4.17	0.24	0.18 ± 0.04^{b}	0.18 ± 0.04^{cd}
18.75 Glyweli	36	5	0.2	0.10 ± 0.00^{b}	0.10 ± 0.00^{d}
25 Glyweli	24	5	0.2	0.10 ± 0.00^{b}	0.10 ± 0.00^{d}
1.25 Kombat	76	3.63	0.28	0.62 ± 0.28^{b}	1.90 ± 0.64^{ab}
2.5 Kombat	76	3.84	0.26	0.60 ± 0.24^{b}	1.50abc $\pm 0.90^{abc}$
5 Kombat	84	3.57	0.28	0.68 ± 0.24^{b}	0.76 ± 0.18^{bcd}
4.69 Weed Crusher	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
9.38 Weed Crusher	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}
18.75 Weed Crusher	0	0	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}

Means in the same column that do not share a letter are significantly different at P≤0.05

Table 5. Seed germination and mean plumule and radicle growth of Sorghum bicolor exposed to pesticides after 5 days.

Concentration (ml/L)	Germination(%)	MGT (days)	MGR	Mean ± SD (cm)	
				Plumule	Radicle
Control	92	2	0.5	5.86 ± 0.98^{a}	6.82 ± 1.46^{a}
4.69 Butaforce	72	2.33	0.43	0.62 ± 0.37^{c}	0.52 ± 0.19^{b}
9.38 Butaforce	48	4.17	0.24	0.48 ± 0.23^{c}	0.30 ± 0.10^{b}
18.75 Butaforce	20	5	0.2	0.04 ± 0.05^{c}	0.04 ± 0.06^{b}
9.38 Glyweli	92	2.35	0.43	0.20 ± 0.00^{c}	0.20 ± 0.00^{b}
18.75 Glyweli	64	2	0.5	0.20 ± 0.00^{c}	0.20 ± 0.00^{b}

25 Glyweli	76	2	0.5	0.20 ± 0.00^{c}	0.20 ± 0.00^{b}
1.25 Kombat	92	2.39	0.42	3.46 ± 0.83^{b}	6.24 ± 0.96^{a}
2.5 Kombat	88	2.91	0.34	2.98 ± 0.77^{b}	5.36 ± 2.04^{a}
5 Kombat	92	3.04	0.33	2.72 ± 0.96^{b}	4.82 ± 2.21^{a}
4.69 Weed Crusher	60	4.47	0.22	0.22 ± 0.16^{c}	0.16 ± 0.06^{b}
9.38 Weed Crusher	20	5	0.2	0.08 ± 0.04^{c}	0.08 ± 0.05^{b}
18.75 Weed Crusher	0	0	0	0.00 ± 0.00^{c}	0.00 ± 0.00^{b}

Means in the same column that do not share a letter are significantly different at P≤0.05.

Fig 1. Zea mays treated with Butaforce, Glyweli, Kombat and Weedcrusher from top to bottom respectively (increasing concentration from left to right) with the solitary dish being the control

Fig 2. Phaseolus vulgaris treated with Butaforce, Glyweli, Kombat and Weedcrusher from top to bottom respectively (increasing concentration from left to right) with the solitary dish being the control.

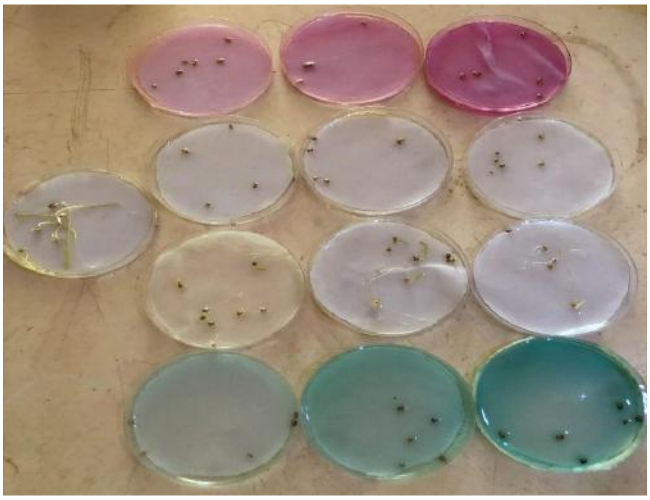

Fig 3. Pennisetum glaucum treated with Butaforce, Glyweli, Kombat and Weedcrusher from top to bottom respectively (increasing concentration from left to right) with the solitary dish being the control.

Fig 4. Oryza sativa treated with Butaforce, Glyweli, Kombat and Weedcrusher from top to bottom respectively (increasing concentration from left to right) with the solitary dish being the control.

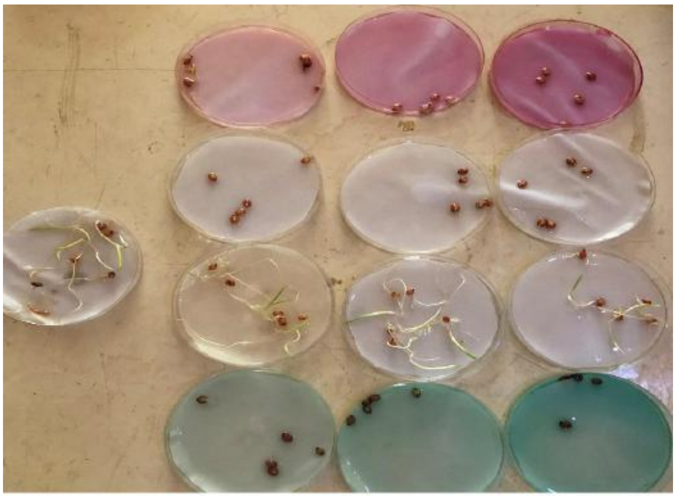

Fig 5. Sorghum bicolor treated with Butaforce, Glyweli, Kombat and Weedcrusher from top to bottom respectively (increasing concentration from left to right) with the solitary dish being the control.

V. CONCLUSION

The findings of this study highlight the differential phytotoxic effects of various pesticide concentrations on the germination and early seedling growth of selected crop species. While certain pesticides, such as Kombat (lambda-cyhalothrin), exhibited growth-promoting effects at lower concentrations, others particularly Weed Crusher (paraquat) caused pronounced inhibitory effects on both plumule and radicle development, especially at higher concentrations. These results emphasize the importance of dose-dependent responses and crop-specific sensitivity to pesticide exposure. Given the potential for adverse developmental impacts, further investigations are warranted to evaluate the environmental persistence, residual toxicity, and selectivity of these agrochemicals. A comprehensive understanding of their physicochemical properties, formulation types, and interactions with plant physiological processes is essential for sustainable crop production. Farmers are encouraged to seek guidance on integrated pest management (IPM) practices to reduce dependency on chemical pesticides and enhance sustainability. Biocontrol agents such as entomopathogenic bacteria can also be integrated into crop protection strategies to reduce reliance on synthetic pesticides and mitigate phytotoxic risks.

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